Microarthropods from two Quebec Woodland Humus forms. II. The Collembola

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Abstract

The Collembola of two Quebec woodland humus forms, a mull under maple (*Acer saccharum* Marsh.) and mor under both beech (*Fagus grandifolia* Ehrh.) and hemlock (*Tsuga canadensis* (L.) Carr.), were investigated. Soil cores were extracted in Tullgren funnels and 58 species in 36 genera recorded. It is estimated they represent no more than a quarter of the entire Quebec collembolan soil fauna. Information is given on geographical distribution and broad ecology of the species involved.

Many have been known from areas near Quebec, but *Archaphorura absoloni* (Börner), *Folsomia sensibilis* Kseneman, and *Isotomodes trisetosus* Denis appear new to North America. These and 15 others are reported for the first time from Canada. About 46 per cent of the species are also known from Europe and it is suggested they reached North America via Arctic islands and international trade.

Among the more abundant species, *Pogonognathellus flavescens americanus* (Schött), *Pseudosinella alba* (Packard) and *P. petterseni* Börner, occurred exclusively in the mull; and *Archaphorura absoloni* (Börner), *Mesaphorura collis* (Bacon), *Hypogastrura* sp. *armata* (Nicolet), *Friesea sublimis* Macnamara, *Paranura caeca* Folsom, *Folsomia sensibilis* Kseneman and *Proisotoma* sp. nr. *borealis* (Axelson) in the mor. Their presence in other situations, however, precludes their being viewed as reliable indicator species of these humus forms. Collembola generally exhibit a wide range of habitats.

Résumé

Il s'agit d'une étude des Collemboles trouvés dans deux types d'humus forestier du Québec, soit dans le mull d'une érablière (*Acer saccharum* Marsh) et dans le mor d'un boisé de hêtres (*Fagus grandifolia* Ehrh.) et de pruches (*Tsuga canadensis* (L.) Carr.). Les échantillons de sol ont été prélevés à l'aide de l'appareil de Tullgren. Nous avons ainsi identifié 58 espèces se groupant sous 36 genres différents, ce qui toutefois ne représenterait que le quart de la faune complète des Collemboles en sol québécois. Pour chacune des espèces trouvées sont données des considérations sur leur répartition géographique et leur écologie générale.

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1 Based on part of a thesis submitted to the Faculty of Graduate Studies and Research of McGill University in partial fulfilment of the requirements for the degree of Doctor of Philosophy (Marshall, 1964). Part I is unnumbered it comprises a preliminary list of Mesostigmata and Trombidiformes (Acarina), see Marshall and Kevan (1964).

Beaucoup de ces espèces ont déjà été signalées dans le Québec ou ses environs mais *Archaphorura absoloni* (Börner), *Folsomia sensibilis* Kseneman et *Isotomodes trisetosus* Denis sont des espèces nouvelles pour l'Amérique du Nord. En plus de celles-là, quinze espèces constituent de nouvelles mentions pour le Canada. Environ 46 p. cent des espèces trouvées se rencontrent en Europe et il est permis de croire qu'elles ont atteint l'Amérique du Nord par les îles de l'Arctique et par suite du commerce international.

Parmi les espèces les plus abondantes, *Pogonognathellus flavescens americanus* (Schött), *Pseudosinella alba* (Packard) et *P. petterseni* Börner se rencontraient exclusivement dans le mull, et *Archaphorura absoloni* (Börner), *Mesaphorura collis* (Bacon), *Hypogastrura* sp. *armata* (Nicolet), *Friesea sublimis* Macnamara, *Paranura caeca* Folsom, *Folsomia sensibilis* Kseneman et *Proisotoma* sp. nr. *borealis* (Axelson), dans le mor. Cependant, comme on trouve les Collemboles dans bien des habitats différents, on ne peut pas conclure que leur présence soit un indice indubitable de l'un ou l'autre de ces types d'humus.

The Collembola or springtails are worldwide in distribution. They inhaitr a variety of places, and are abundant in soil. Springtails often occur in lage aggregates and population size varies considerably in different habitats. Recent estimates have ranged from 1,000 to 1,000,000 per cubic metre (Christiansen, 1964). The rounded figures of 107,000 and 212,000 per cubic metre for a mull and mor in Quebec are probably representative of forest soils in this region (Marshall, 1964).

Except for their taxonomy, the Collembola have not been extensively investigated (*cf.* Salmon, 1964, 1965). Some species are of economic importance, infecting well-water, stored products and dwellings, and causing damage to cultivated mushrooms, seedlings, greenhouse plants and field crops (Folsom, 1933; Maynard, 1951; Wallace, 1959; Edwards, 1962). Collembolan parasites of animals are unknown, although Scott *et al.* (1962) have listed some common domestic species, two of which cause pruritic dermatitis in man.

Springtails are of special interest to soil biologists, because of their large numbers in the soil, their possible use as indicator species of soil conditions, and their role in the decomposition of organic matter. Of the little work published on Canadian Collembola, Arctic species have received most attention (Kevan, 1961). This paper provides information on species occurring in southern Quebec.

Site and Sampling

Details of sites, sampling and extraction methods have been given elsewhere (Marshall, 1964). The location is in the Morgan Arboretum, Macdonald College, Ste. Anne de Bellevue, west Montreal Island, Quebec. The Arboretum forms part of the Middle Ottawa Section of the Great Lakes – St. Lawrence Forest Region (Rowe, 1959). The elevation ranges from 38 to 53 metres above sea level. Stanfield (1915) described the geology as Palaeozoic Beckmantown Calciferous Dolomite, covered by boulder and Leda clays, and Saxicava sand. The climate is a mesothermal humid type (Sanderson, 1948), with an average precipitation of 1061 mm. evenly distributed throughout the year. Mean monthly temperatures are 21.3°C for July and – 9.2°C for January.

The soils represented two humus forms, mull and mor — or raw humus of Kubiëna (1953) — and supported three different cover-types each separated about 300 metres along a transect.

Site 1, a mull, was a brown-forest soil derived from a clay loam. Samples were divided into litter (0.4 – cm. thick), and two 5 – cm. thick sections of the mineral layer. The pH values of the two mineral sections were 6.9 and 6.6. The mull supported a mixed hardwood, mainly sugar maple (*Acer saccharum* Marsh.) 30 to 40 years old.

Site 2, a mor, was a gleyed-podzol on a stone-free loamy sand. Samples were divided into three zones: L-F_1 (4.3 – cm. thick), F_2-H (3.3 – cm. thick) and A_2-B (5 – cm. thick). These had pH values of 4.6, 4.3 and 4.5 respectively. An 80-year-old stand of beech (*Fagus grandifolia* Ehrh.) was present to the virtual exclusion of all other tree species.

Site 3, a mor, was on a parent material similar to site 2. Samples were also divided into three zones: L-F_1 (3.2 – cm. thick), F_2-H (3.1 – cm. thick) and A_2-B (4.1 – cm. thick), and had pH values of 4.5, 4.4 and 4.8 respectively. The tree cover was predominately hemlock (*Tsuga canadensis* (L.) Carr.), about 100 years old.

The method of sampling was similar for all three soils. Two soil cores 7.5 cm. in diameter were taken with a tubular borer from each site monthly from June to November, 1960. Cores were subdivided, as described above, and extracted in modified Tullgren funnels (*cf.* Haarløv, 1955). Specimens were mounted on slides for identification, and these have been deposited in the Lyman Entomological Museum, Macdonald College, Identifications were largely made from the literature, especially Mills (1934), Maynard (1951), Gisin (1960) and Stach (1947-1963), but representatives of the species were ckecked by Dr. W. R. Richards, Ottawa. Any errors, however, resulting from checking authenticated specimens against the bulk of the material are attributable only to the author.

Annotated list of species obtained

The general classification of the Collembola in the list given below follows Salmon (1964), but genera and species are arranged alphabetically. Of the 58 species collected, 5 appear to be new to science, but further studies would be necessary to ascertain their exact status. Records of species not previously reported for Canada or Alaska are marked with an asterisk (*). Against each species is also a brief note on distribution and ecology. Distribution records are taken mainly from Salmon (*op. cit.*). References are cited only in respect of collection sites in Canada and of habitat data that are not mentioned by Salmon. The site numbers have already been given, and letters in parentheses indicating soil horizons follow the classification of Kevan (1962), except L, which represents the litter layer and M and N, which signify two mineral soil horizons at depths of 0 – 5 and 5 – 10 centimetres respectively.

ONYCHIURIDAE

**Archaphorura absoloni* (Börner, 1901) — Sites 2, 3 (L-F_1, F_2-H), 28 ex.

Type from Germany. Distribution: Greenland, Europe.

Habitat: in forest soils (Haybach, 1959).

Note: Gisin (1960) considers *Onychiurus affinis* Ågren, 1903 to be a synonym of *Onychiurus* [= *Archaphorura*] *absoloni*, but there is some doubt as to the identity of these two species and Salmon (1964) separates them. If Gisin is correct, *A. absoloni* has been previously recorded as *O. affinis* from Canada by Hammer (1953) at Banff in Alberta, Yellowknife in the North West Territories and Churchill in Manitoba. Habitats given for these records include moss, liverwort, lichen and meadow.

Hymenaphorura subtenuis (Folsom, 1917) — Sites 1, 2, 3 (M. N, L-F_1, F_2-H), 43 ex.

Type from northeastern United States. Distribution: North America; in Canada from Ontario (James, 1933); Reindeer Station and Coppermine in the North West Territories (Hammer, 1953) and Cloverdale in British Columbia (MacNay, 1957).

Habitat: in moss and reindeer lichen, in dead leaves (Hammer, 1953); in leaf mould, under logs and stones (Maynard, 1951); in forest litter (Bellinger, 1954; Scott, 1961).

**Mesaphorura clavata* (Mills, 1934) — Sites 1, 2 (L, M, L-F_1, F_2-H), 60 ex.

Type from Iowa. Distribution: Connecticut, Idaho, Iowa, New York State.

Habitat: beneath decaying wood and in humus (Mills, 1934); under sticks and stones on sandy soil (Maynard, 1951); in forest soil (Bellinger, 1954).

Mesaphorura collis (Bacon, 1914) — Site 1 (M, N), 3 ex.

Type from California. Distribution: Holarctic; in Canada from Reindeer Station, Yellowknife and Coppermine in the North West Territories (Hammer, 1953).

Habitat: in moss, in lichen, peat soil, in dead leaves and needles, dry reindeer lichen heath (Hammer, 1953); in humus (Mills, 1934); in grassland and forest litter (Bellinger, 1954).

Mesaphorura granulata (Mills, 1934) — Sites 1, 2, 3, (L, M, N, L-F_1, F_2-H, A_2-B), 49 ex.

Type from Iowa. Distribution: France, Connecticut, Idaho, Iowa, North Carolina; in Canada from Churchill in Manitoba (Hammer, 1953).

Habitat: moss and humus (Mills, 1934); in low lawn-like heath vegetation (Hammer, 1953); in grassland and forest litter (Bellinger, 1954); in rodent nests (Wray and Knowlton, 1961); in caves (Christiansen *et al.*, 1961).

**Mesaphorura* sp., *M. granulata*-group — Site 2 (L-F_1, F_2-H, A_2-B), 6 ex.

This species appears to be new.

Mesaphorura krausbaueri Börner, 1901 — Sites 1, 2, 3 (M, N, L-F_1, F_2-H, A_2-B), 30 ex.

Type from Germany. Distribution: Cosmopolitan; in Canada from the Rocky Mountains at Banff in Alberta, and Richardson Mountains, Reindeer Station and Yellowknife in the North West Territories (Hammer, 1953).

Habitat: pond shore (Haarlφv, 1957); in moss (Stach, 1954; Cassagnau 1961) in reindeer lichen and liverwort, in dead leaves, peaty soil (Hammer, 1953); in grassland (Bellinger, 1954); in forest litter (Winston, 1956; Haybach, 1959; Poole, 1964; Petersen, 1965); in caves (Christiansen *et al.*, 1961).

Onychiurus sp., *O. fimetarius*-group — Sites 1, 2, 3 (M, L-F_1, F_2-H, A_2-B), 61 ex.

Note: It is difficult to determine species of this group satisfactorily at the present time. This species may have been recorded previously from Canada and elsewhere. The group is widely distributed in the world and occurs in a variety of damp places including flowerboxes in houses and greenhouses.

Protaphorura sp., *P. armata*-group — Sites 1, 2, 3 (M, L-F_1, F_2-H, A_2-B), 115 ex.

Note: As for *O. fimetarius*-group above.

HYPOGASTRURIDAE

Hypogastrura sp., ? *H. armata* (Nicolet, 1841) — Sites 2, 3 (L-F_1, F_2-H, A_2-B), 111 ex.

Type (of *H. armata*) from Europe. Distribution: Cosmopolitan; in Canada from Ontario and British Columbia (Maynard, 1951; Wade, 1954; MacNay, 1957); Richardson Mauntains and Coppermine in the North West Territories and Churchill in Manitoba (Hammer, 1953); Ellesmere Island (Hammer, 1953a); Victoria Island in the North West Territories (Mills and Richards, 1953).

Habitat (of *H. armata*): On pools of water, in moss, among leaves, on moist soil, under bark (Maynard, 1951); in grassland (Haarlφv, 1957); in forest soils (Haybach, 1959); in houses (Stach 1949); in rodent nests (Wray and Knowlton, 1961).

Hypogastrura sp., *H. manubrialis*-group — Site 2 (L-F_1), 1 ex.

Note: It is difficult to determine species of this group satisfactorily at present and it would serve no purpose to indicate distribution or habitat since what was formerly known as *H. manubrialis* (Tullberg, 1869) is now known to comprise a complex of species. The group is widely distributed in the world and occurs in a variety of damp places.

It is conceivable that it may have been recorded previously from Canada.

**Hypogastrura* sp., ? nov. — Site 2 (L-F_1), 3 ex.

Willemia anophthalma Börner, 1901 — Sites 1, 2, 3 (M, N, L-F_1, F_2-H, A_2-B), 71 ex.

Type from Germany. Distribution: Greenland, Europe; in Canada from Reindeer Station, Yellowknife and Coppermine in the North West Territories (Hammer, 1953); a single specimen from Ellef Ringnes Island (McAlpine, 1965) is probably this species.

Habitat: in moss, liverwort, lichen (Hammer, 1953); in grassland (Bellinger, 1954); in forest soils (Haybach, 1959; Petersen, 1965); in hothouses (Stach, 1949); in caves (Salmon, 1964).

BRACHYSTOMELLIDAE

Odontella sp.$_1$ — Site 2 (L-F_1), 2 ex.

Note: The taxonomic characters were not sufficiently clearly visible for specific determination. This species may have been recorded previously from Canada.

Onontella sp.$_2$ — Site 2 (F_2-H), 3 ex.

Note: as above for *Odontella* sp.$_1$

ANURIDAE

Aphoromma sp., ?*A. granaria* (Nicolet, 1847) — Sites 2, 3 (L-F_1, F_2-H), 4 ex.

Type (*of A. granaria*) from France. Distribution: Cosmopolitan; in Canada from Ontario (James, 1933); Richardson Mountains, Reindeer Station and Coppermine in the North West Territories (Hammer, 1953), Ellesmere Island (Hammer, 1953a).

Habitat (of *A. granaria):* on lake shores (James, 1933); in lichen, moss, clay soil, in wet ooze with leaves and moss, in heath (Hammer, 1953); from humus soil (Nosek, 1960).

Friesea sublimis Macnamara, 1921 — Sites 2, 3 (L-F_1), 31 ex.

Type from Ontario. Distribution: Europe, New York State; in Canada only from Ontario (Macnamara, 1921; James, 1933).

Habitat: Under bark (Macnamara, 1921, 1924).

NEANURIDAE

Micanurida sp., nr. *pygmaea* Börner, 1901 — Sites 1, 2, 3 (L, L-F_1, F_2-H, A_2-B), 62 ex.

Type (of *M. pygmaea*) from Germany. Distribution: Greenland, Europe. Connecticut; in Canada from Reindeer Station and Yellowknife in the North West Territories and from Churchill in Manitoba (Hammer, 1953).

Habitat (of *M. pygmaea*): in moss, under loose bark of mouldy tree trunks, in needle litter, and vegetable soil (Stach, 1949a); in peaty soil (Hammer, 1953); in grassland (Bellinger, 1954; Haarlφv, 1957); in forest soils (Haybach, 1959; Petersen, 1965).

Neanura sp., ? *N. muscorum* (Templeton, 1835) — Site 1 (M), 1 ex.

Type (of *N. muscorum*) from Ireland? Distribution: Europe, Australia, New Zealand, Mexico, middle and eastern United States; in Canada from Akpatok Island (Brown, 1932), Ontario (James, 1933); British Columbia (Wade, 1954).

Habitat (of *N. muscorum*): pond shore (Haarlφv, 1957); in moss and humus (Nosek, 1960); under bark, stump, damp log (James, 1933); in rotten logs and leaves in moist soil (Maynard, 1951); in forest soils (Haybach, 1959; Cassagnau, 1961; Poole, 1962); in caves (Stach, 1951).

**Paranura caeca* Folsom, 1916 — Sites 2, 3 (L-F_1, A_2-B), 12 ex.

Type from Illinois. Distribution: California, Illinois, Iowa, North Carolina. Habitat: leaf mould (Mills, 1934).

**Pseudachorutes aureofasciatus* (Harvey, 1898) — Sites 1, 2 (L, L-F_1), 2 ex.

Type from Maine. Distribution: North America.

Habitat: in decaying wood (Maynard, 1951); in litter (Scott, 1960).

**Pseudachorutes dilatatus* (MacGillivray, 1893) — Site 2 (L-F_1), 1 ex.

Type from New York State. Distribution: New York State only.

Habitat: soil.

**Pseudachorutes simplex* Maynard, 1951 — Sites 1, 2 (M, L-F_1), 2 ex.

Type from New York State. Distribution: New York State only.

Habitat: in moss and on sticks (Maynard, 1951).

**Pseudachorutes* sp., ? nov.— Site 2 (L-F_1), 1 ex.

TOMOCERIDAE

Pogonognathellus flavescens americanus (Schött, 1891) — Site 1 (L, M), 8 ex.

Type from United States. Distribution: North America; in Canada from Ontario (James, 1933); Richardson Mountains, Reindeer Station and Yellowknife in the North West Territories (Hammer, 1953); Perry River, North West Territories (Mills and Richards, 1953).

Habitat: on lichen heath, in meadow (Hammer, 1953); in pine litter (Knight, 1961).

Note: According to Knight (1958), the variety *americanus* might be a distinct species. *P. flavescens*, a species of Holarctic distribution, has at least three other "varieties" that have been recorded previously in Canada (*cf.* Wade, 1954; Salmon, 1964; Judd, 1965; Martin, 1965).

ISOTOMIDAE

**Australomia* sp. nr. *inaequalis* (Bagnall, 1949) — Site 2 (L-F_1), 1 ex.

Type (of *A. inaequalis*) from British Isles. Distribution: England and Northern Ireland.

Habitat (of *A. inaequalis*): soil ?

Ballistrura sp.$_1$ — Site 3 (L-F_1, F_2-H), 2 ex.

Note: these specimens were juveniles; specific identification is therefore impossible for the present. It is possible that this species has been recorded previously in Canada.

Ballistrura sp.$_2$ — Site 1 (M), 3 ex.

Note: Specimens were poorly mounted and the characters necessary for specific determination could not be seen. It is possible that this species has been recorded previously from Canada.

Cephalotoma grandiceps (Reuter, 1891) — Sites 1, 3 (M, L-F_1, F_2-H), 18 ex.

Type from Siberia. Distribution: Russia, Siberia, Alaska, United States; in Canada from Ontario (James, 1933); Richardson Mountains and Reindeer Station in the North West Territories (Hammer, 1953).

Habitat: in withered *Cassiope*, moss and liverwort, lichen heath, wet dead leaves (Hammer, 1953); in leaf mould (James, 1933); in forest soil (Macnamara, 1924).

Folsomia duodecimsetosa Hammer, 1953 — Sites 1, 2, 3 (L, M, N, L-F_1, F_2-H, A_2-B), 481 ex.

Type from northern Canada. Distribution: Yellowknife and Coppermine in the North West Territories and Churchill in Manitoba.

Habitat: in moss, lichen, in damp depression among willow bushes, soil in heath vegetation, on *Dryas* plains near the beach, on tussocks in tundra partly grown with heath vegetation (Hammer, 1953).

**Folsomia sensibilis* Kseneman, 1936 — Sites 2, 3 (L-F_1, F_2-H, A_2-B), 104 ex.

Type from Czechoslovakia. Distribution: Jan Mayen Island and Europe.

Habitat: in humus and litter (Cassagnau, 1961).

**Heteroisotoma andrei* (Mills, 1934) — Sites 1, 2 (L, N, L-F_1, F_2-H), 24 ex.

Type from Iowa. Distribution: Iowa only.

Habitat: moss (Mills, 1934).

Isotoma tigrina olivacea (Tullberg, 1871) — Sites 1, 3 (L, M, N, F_2-H, A_2-B), 7 ex.

Type from Europe. Distribution: Cosmopolitan; in Canada from Akpatok Island (Brown, 1932) Ontario (James, 1933; Folsom, 1937); Richardson Mountains, Yellowknife and Coppermine in the North West Territories and Churchill in Manitoba (Hammer, 1953); Ellesmere Island (Hammer, 1953a; Oliver, 1963).

Habitat: sea and lake shore, moss, lichen, grassland, moorland and woodland (Hammer, 1953; Haarlφv, 1957); in forest soils (Scott, 1962; Poole, 1962).

Note: Two of these specimens may be regarded as f. *stachi* Denis, 1929.

Isotoma violacea Tullberg, 1876 — Site 1 (F_2-H), 1 ex.

Type from northern Europe. Distribution: Holarctic; in Canada from Ontario (Maynard, 1951; Martin, 1965); Richardson Mountains, Reindeer Station, Yellowknife and Coppermine in the North West Territories and Churchill in Manitoba (Hammer, 1953); Ellesmere Island (Hammer, 1953a); British Columbia (Wade, 1954). Ellef Ringnes Island (McAlpine, 1964, 1965).

Habitat: sea and lake shore in moss and lichen, grassland and in forest soil (Haarlφv 1957; Nosek, 1961); in heath (Hammer, 1953); in rodent nests (Wray and Knowlton, 1961).

**Isotoma* sp., ? nov. — Sites 1, 3 (L, M, L-F_1, F_2-H), 29 ex.

**Isotomedia achromata* (Bellinger, 1952) — Sites 1, 2, 3 (M, L-F_1, F_2-H, A_2-B), 91 ex.

Type from Connecticut. Distribution: Connecticut, North Carolina (Wray, 1959).

Habitat: humus in forest soils (Bellinger, 1952); in leaf mould (Wray, 1959).

**Isotomiella minor* (Schäffer, 1896) — Sites 1, 2, 3 (L, M, N, L-F_1, F_2-H, A_2-B), 571 ex.

Type from Germany. Distribution: Cosmopolitan, but so far unrecorded for Canada.

Habitat: on lake shore (Petersen, 1965); in grassland and forest litter (Bellinger, 1954); in mineral soil where it is able to penetrate relatively deeply (Haarlφv, 1957); in rodent nests (Wray and Knowlton, 1961); and in caves (Salmon, 1964).

**Isotomodes trisetosus* Denis, 1923 — Sites 1, 3 (M, L-F_1, F_2-H, A_2-B), 51 ex.

Type from France. Distribution: Central Europe, Madeira, Azores and Peru (Gama, 1963).

Habitat: in moss, under stone, in dead leaves, soil and young eucalyptus forest (Gama, 1963).

Parisotoma notabilis (Schäffer, 1896) — Sites 1, 2, 3 (L, M, N, L-F_1, F_2-H, A_2-B), 163 ex.

Type from Germany. Distribution: Cosmopolitan; in Canada from the Rocky Mountains near Banff in Alberta, Yellowknife and Coppermine in the North West Territories, and from Churchill in Manitoba (Hammer, 1953); from Ontario and Quebec (Sharma and Kevan, 1963).

Habitat: on river banks, in meadows, in heath (Hammer, 1953); an almost ubiquitous species but with a preference for woodlands (Haarløv, 1957); a general inhabitant of litter but also found in moss, old tree stumps, moist humus soil, under flower pots in greenhouses, and in caves (Sharma and Kevan, 1963).

**Proisotoma* sp. nr. *borealis* (Axelson, 1905) — Site 3 (L-F_1, F_2-H), 84 ex.

Type (of *P. borealis*) from Finland. Distribution: Europe.

Habitat (of *P. borealis*): in soil?

Note: Dr. W. R. Richards (*in litt.*, 1964) is of the opinion that this species is probably new.

**Varisotoma minima* (Absolon, 1901) — Site 1 (M), 3 ex.

Type from Moravia. Distribution: Europe, Algeria, Russia, Iowa.

Habitat: mostly under the bark of mouldy stumps, in caves (Stach, 1947).

ENTOMOBRYIDAE

Entomobrya clitellaria Guthrie, 1903 — Sites 1, 2 (L, M, N, L-F_1, A_2-B), 24 ex.

Type from Minnesota. Distribution: Australia, New Zealand, North America; in Canada from Ontario; Quebec (Pielou and Matthewman, 1966).

Habitat: common beneath maple and elm bark (James, 1933); in fungi (Pielou and Matthewman, 1966); in soil and in houses (Scott, 1959).

Note: There is some confusion as to the exact taxonomic status of this species (*cf.* Stach, 1963). It has been regarded as a form of *E. atrocincta* Schött, 1896, which has many other named forms. For example, *E. atrocincta albicollis* Franklin, 1905, is known from British Columbia (Wade, 1954).

Entomobrya $sp._1$ — Site 1 (N), 1 ex.

Note: this specimen was poorly mounted, and characters necessary for specific identification could not be seen. The species has perhaps been recorded previously from Canada.

Entomobrya $sp._2$ — Sites 2, 3 (L-F_1), 6 ex.

Note: These were juveniles, therefore specific identification was impossible. The species may have been recorded previously from Canada.

Entomobrya $sp._3$ — Sites 2, 3 (L-F_1, A_2-B), 3 ex.

Note: as above for *Entomobrya* $sp._2$.

Pseudosinella alba (Packard, 1873) — Site 1 (L, M, N), 77 ex.

Type from Massachusetts. Distribution: Cosmopolitan; in Canada from Ontario (James, 1933); British Columbia (Wade, 1954); Quebec (Sharma and Kevan 1963a).

Habitat: in grassland (Haarlφv, 1957; Petersen, 1965); in forest soil (Sharma and Kevan, 1963a; Poole, 1964); in rodent nests (Wray and Knowlton, 1961); in caves (Christiansen *et al.*, 1961).

Pseudosinella petterseni Börner, 1901 — Site 1 (L, M, N), 7 ex.

Type from Germany. Distribution: Europe, North and South America; in Canada from Ontario and Quebec (Sharma and Kevan, 1963a).

Habitat: grassland and woodland (Haarlφv, 1957); in forest soil (Scott, 1963; Sharma and Kevan, 1963a); in caves (Christiansen *et al.* 1961).

Willowsia nigromaculata (Lubbock, 1873) — Sites 1, 2, 3 (L, M, N, L-F_1 F_2-H, A_2-B), 49 ex.

Type from England. Distribution: Holarctic and Australia (Nosek, 1962); in Canada from Ontario (James, 1933); Ungava Bay in Quebec (Hammer, 1953).

Habitat: in reindeer lichen and moss (Hammer, 1953); bunches of grass (Nosek, 1962); rarely beneath bark (Mills, 1934); on dry board (James, 1933); in buildings (Mills, 1934; Maynard, 1951).

Note: this species was found to be common in the laboratory from May to September and may not actually have come from the soil, although it has been recorded in similar situations by many authors. According to Haarlφv, (1957), *Lepidocyrtinus domesticus* (Nicolet, 1841) could be collected with Tullgren funnels in the absence of soil samples.

NEELIDAE

**Megalothorax incertus* Börner, 1903 — Sites 1, 2, 3 (M, L-F_1), 8 ex.

Type from Sicily. Distribution: Europe, Australia, New Zealand, North America.

Habitat: in humus (Mills, 1934); in caves (Salmon, 1964).

Megalothorax minimus Willem, 1900 — Sites 1, 2, 3 (L, M, N, L-F_1, F_2-H, A_2-B), 130 ex.

Type from Europe. Distribution: Cosmopolitan; in Canada from Reindeer Station, Yellowknife and Coppermine in the North West Territories (Hammer, 1953); Ellesmere Island (Hammer, 1953a; Oliver, 1963).

Habitat: in moss, liverwort, in dead leaves, in heath (Hammer, 1953); in grassland (Haarlφv, 1957); in forest soil (Poole, 1962); in greenhouses (Salmon, 1964); in caves (Christiansen *et al.*, 1961).

Megalothorax sp.— Site 1 (L, M), 3 ex.

Note: These specimens were poorly preserved, therefore positive identification was not possible. This species may have been recorded previously from Canada.

SMINTHURIDAE

Arrhopalites sp.$_1$, *A. pygmaeus*-group — Sites 1, 2, 3 (L, M, N, L-F_1, F_2-H, A_2-B), 18 ex.

Note: All specimens were juveniles, therefore exact specific identification was impossible. This species may have been recorded previously from Canada. The group is widely distributed with many representatives living in caves.

Arrhopalites sp.$_2$, *A. pygmaeus*-group — Sites 2, 3 (L-F_1, A_2-B), 4 ex.

Note: as for *Arrhopalites* sp.$_1$ above.

Bourletiella sp.— Site 2 (L-F_1, F_2-H), 2 ex.

Note: Both specimens were males, therefore specific identification was not possible. This species may have been recorded previously from Canada.

Ptenothrix sp., ? *P. uncilor* (Harvey, 1893) — Site 1 (L, M), 2 ex.

Type (of *P. unicolor*) from Maine. Distribution: North America; in Canada from Ontario (James, 1933); British Columbia (Spencer, 1948; Wade, 1954).

Habitat (of *P. unicolor*): under rubbish, in woodlands on *Agaris* and *Boleti*, under the loose bark of stumps, under boards and rubbish, in meadows and pastures (Harvey, 1893); in woodlands (Maynard, 1951).

Sminthurides sp., ? *S. occultus* Mills, 1934 — Site 3 (L-F_1), 1 ex.

Type (of *S. occultus*) from Iowa. Distribution: Iowa, New York State, North Carolina; in Canada from Ontario, Manitoba (Maynard, 1951); Rindeer Station and Yellowknife in the North West Territories (Hammer, 1953).

Habitat (of *S. occultus*): on river bank in mud, in *Sphagnum*, in meadow with sparse moss (Hammer, 1953); in humus (Mills, 1934); on sticks lying on the ground (Maynard, 1951).

Sminthurinus aureus (Lubbock, 1862) — Sites 1, 3 (M, N, L-F_1), 6 ex.

Type from England. Distribution: Cosmopolitan; in Canada from Ontario (James, 1933; Martin, 1965).

Habitat: in moss (Stach, 1956); in grassland and forest litter (Bellinger, 1954; Haarlϕv, 1957); old tree stumps, on rocks, under bark of trees, on low plants of meadows and gardens, under flowerpots in dwellings (Stach, *loc. cit.*).

Sminthurinus elegans (Fitch, 1863) — Site 1 (L, M, N), 9 ex.

Type from New York State. Distribution: Holarctic; in Canada from Ontario (James, 1933).

Habitat: in moss (James, 1933); common soil species in lawns and pastures, Maynard (1951).

Discussion

The results of this survey must be interpreted with the understanding that the list does not represent the entire collembolan fauna of the habitats investigated. Certain microarthropods are not efficiently recovered by the type of funnel method employed (*cf.* Murphy, 1962). Some onychiurids with poorly-developed locomotory organs often fail to emerge from soil, while certain tomocerids with well-developed furcula (springing organ) were picked off the ground of the experimental site but were not taken in soil removed to the laboratory for extraction. The data are nevertheless sufficient to provide a reasonable indication of the species composition and population size to be expected in Canadian forest-soils.

The soils of the restricted areas studied are rich in species, but the 58 reported here probably represent no more than a quarter of the species that may be present in Quebec soils. This may be inferred from the results obtained from comparable areas in widely separated regions of the world. Thus, Salmon (1949) stated that 278 species are known from New Zealand; Cassagnau (1961) recorded 206 species from southeastern France, and Maynard (1951) found 200 species in New York State.

At least 46 per cent of the species from this study have been recorded in Europe. Mills (1939) estimated that 31 per cent of North American Collembola were Holarctic or cosmopolitan in distribution, and Hammer (1953) showed that about 50 per cent of northern Canadian species were also well known from Europe. It has also been observed that species formerly found only in northern European areas have recently appeared in North America (Wray, 1962). Are Collembola migrating between the continents?

Certainly, Woolley (1960) and McAlpine (1965) have suggested wind, floating objects, birds and mammals as possible means of distribution of small arthropods. The continuous distribution of some Collembola in Europe, throughout the Arctic islands of both hemispheres and in North America is evidence that they are probably naturally circumpolar and circumboreal. However, other species are not found in the Arctic or Subarctic and the assistance of man in their distribution is not improbable. Gates (1965) suggested that exotic earthworms were accidentally brought into North America by earth used as ballast, with soil on imported plants, with vegetables for ships stores or for sale, and in organic fertilizers. A large number of insect species are also known to have been introduced, particularly into Newfoundland and Nova Scotia, in the same way (Lindroth, 1957). Conceivably soil collembola are spread by similar means (Wray, 1959, 1959a).

Although it is not the purpose of this paper to discuss detailed aspects of distribution, it may be noted that few species occurred exclusively in any one humus form. Among those present in relatively large numbers, *Pogonognathellus flavescens americanus*, *Pseudosinella alba* and *P. petterseni* were recorded from only the mull, whereas *Archaphorura absoloni*, *Mesaphorura collis*, *Hypogastrura* sp. ? *armata*, *Friesea sublimis*, *Paranura caeca*, *Folsomia sensibilis* and *Proisotoma* sp. nr. *borealis* were extracted from only the mor. However, it

would be erroneous to suggest these groups constitute reliable indicators of the soil or humus type they inhabit, snice these species also occur in other situations.

Many of the species exhibit a wide range of habitats, living in moss, lichen, grasslands, forests and some even in dwellings and caves. A single homogeneous habitat for any collembolan does not seem to exist (Petersen, 1965). This makes it difficult to select indicator species, as opposed to species complexes, in the characterization of different soil types.

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